DISTRIBUTION PATTERNS OF DIATOMS IN CEDAR RUN[1]

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Abstract. The diatom communities of Cedar Run, Champaign County, Ohio were studied to determine their spatial and seasonal variation. Collections were obtained using glass slides as an artificial substratum and the diatom community was determined by identifying and counting approximately 1,000 valves on each slide. There were 190 diatom taxa identified, 82 of which were new records for Ohio. A multivariate analysis of the data resulted in unique clustering of points for each station, indicating a heterogeneous diatom assemblage in Cedar Run. Results were interpreted as indicating that areal effect on diatom community patterns masked that of seasonal influence in Cedar Run. A seasonal pattern was apparent when data for each station were considered separately from other stations.

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Studies concerning riverine diatoms are numerous. Attempts to relate ecological parameters to algal populations were perhaps best expressed in early studies by Butcher (1932) and Schroeder (1939). More recent studies include those of Round (1957), Douglas (1958), Cholnoky (1960), Hohn and Hellerman (1963), Fee (1967), Shobe (1967), Kalinsky (1969), Cairns *et al* (1970), Lowe (1972), and Lowe and McCullough (1974).

The present paper assesses the areal and seasonal variations of diatom populations in a small, slightly alkaline stream, Cedar Run, in Champaign County, Ohio. The diatom flora of Cedar Run, as determined by growth on an artificial substratum was identified, and the populations in representative samples counted. From these data the nature of the diatom community was determined.

DESCRIPTION OF STUDY AREA

Cedar Run has its origin in the northern most part of Cedar Bog, an arbor vitae bog in Champaign County, approximately six miles south of Urbana, Ohio. The stream is characterized by a pH generally in the range 7.2 to 7.8, a strong HCO_3^-–$CO_3^=$ buffer system, and a relatively constant temperature and water level. See the November 1974 issue of The Ohio J. Sci. for additional information and map (Frederick, 1974).

Three stations were established as diatom collecting sites in Cedar Run.

STATION 1 was in an area of the stream designated as "Cedar Run-North" by Briggs (1972) and was located approximately 500 meters north of the bridge on Woodburn Road. The station was characterized by a dark-colored silty stream bed devoid of emergent vegetation. The stream flowed through an open marl meadow having numerous seepage areas.

STATION 2 was located in the West Branch of Cedar Run approximately 15 meters north of the bridge on Woodburn Road and was characterized by the luxuriant growth of *Nasturtium officinale* R. Br. and *Chara globularis* var. *virgata* f. *macounii* (Wood). *Chara* was not present during the winter months, but *Nasturtium* was prominent the year round. Current was negligible, due to fallen logs and branches in the stream, and the station was heavily shaded by deciduous trees.

STATION 3 was in "Cedar Run-South" as designated by Briggs (1972), approximately 750 meters south of the confluence of the East and West Branches and 3 meters north of the bridge on Dallas Road. The station was char-

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acterized by the hard sandy bottom of the main channel, bordered on either side by deep, black muck. Extensive growths of *Nasturtium*, *Chara*, and *Veronica anagallis-aquatica* L. occupied the shallow regions on either side of the channel.

MATERIALS AND METHODS

Collections were obtained from each station by use of an artificial substratum consisting of standard microscope slides (7.62 x 2.54 cm) held in a modified diatometer (Kalinsky, 1969). (Note: the term "diatometer," as used in this paper, refers to a device utilizing an artificial substratum for collecting diatoms, and does not refer to the registered device known as the "Catherwood Diatometer").

Slides were exposed for 21 days, removed from the diatometer, and the diatoms scraped from the slides. The samples were cleaned by the H_2O_2–$K_2Cr_2O_7$ method of Van der Werff (1955), and aliquots mounted on glass slides according to the method of Patrick and Reimer (1966). The diatom community of each slide was identified and counted according to the method of Patrick *et al* (1954). Each taxon was recorded, and its frequency of occurrence in a 1,000 valve count noted. To encourage randomness, independent transections were made from one side of the cover slip to the other to encounter at least 1,000 valves. Specimens represented by only one frustule or valve were excluded because of difficulty with positive identification. The data, including date and site of collection, taxa encountered, and frequency of occurrence of each taxon were transferred to IBM cards for computer analysis.

Chemical and physical data for each station was determined on three occasions: 27 October 1970, 5 February 1971, and 3 June 1971. Cations were analyzed by atomic absorption spectrometry, anions and O_2 by Hach procedures, and temperature by a mercury thermometer.

TABLE 1

Diatom taxa from Cedar Run. Relative abundance was calculated as percent of total from each station (16 September 1970 through 22 August 1971).

Genus species variety or form	% Relative Abundance at Stations		
	1	2	3
Achnanthes	22.30	22.68	33.21
clevei	—	0.12	0.05
exigua	0.01	0.02	—
heterovalvata*	+	0.02	0.08
flexella*	0.20	0.02	0.08
lanceolata	0.66	2.11	0.17
dubia	0.05	0.70	0.61
lapponica*	0.28	0.02	0.13
ninckei*	0.54	0.33	0.12
linearis*	0.44	0.27	0.18
minutissima	20.11	24.82	31.75
peragalli	—	—	—
fossils*	+	—	0.03
Amphipleura			
pellucida*	0.36	0.03	0.01
Amphora	0.25	1.09	0.16
michiganensis*	0.02	+	—
ovalis	—	—	—
affinis	0.17	0.29	0.05
pediculus	0.05	0.52	0.11
submontana	—	0.16	—
veneta	+	0.02	—
sp	+	0.09	—
Anomoneis			
vitrea*	0.39	—	0.07
Caloneis	0.99	0.25	0.16
alpestris*	0.06	+	0.02
bacillum	0.81	0.24	0.11
limosa*	0.11	0.01	0.02
Campylodiscus			
noricus			
hibernica*	+	0.02	—
Cocconeis	9.60	23.14	41.35
dimunita*	0.02	0.48	0.23
pediculus	0.02	0.14	2.83
placentula	6.22	4.00	20.03
euglypta	0.27	13.14	2.73
lineata	3.08	5.39	15.50
thumensis*	—	—	0.02
Cyclotella	+	8.42	0.38
kutzingiana*	—	0.09	+
meneghiniana	—	0.06	0.08
striata	+	8.26	0.19
Cymbella	3.64	0.96	0.73
affinis	0.02	—	+
amphicephala	0.48	0.06	0.05
angustata*	0.04	+	—
cesati*	1.07	0.24	0.14
cistula	0.07	—	0.01
delicatula*	0.54	0.26	0.07
laevis	0.43	0.26	0.07
microcephala*	0.54	0.07	0.17
subaequalis*	0.20	0.02	+
thumensis	0.01	0.02	0.04
ventricosa	0.08	0.26	0.20
sp	0.06	—	—
sp	0.11	—	—

*new record for Ohio.
sp=unidentified species.
—not present.
+present at relative frequency less than 0.01%.

TABLE 1. *Continued.*

Genus species variety or form	% Relative Abundance at Stations 1	2	3
Denticula	0.32	0.04	0.08
elegans*	0.06	—	+
kittoniana*	0.26	0.04	0.07
Diatoma	2.36	0.01	0.03
hiemale	—	—	0.02
tenue	—	—	—
elongatum	2.36	—	+
vulgare	—	—	—
linearis	—	0.01	+
Diploneis	5.17	2.70	1.81
elliptica*	0.10	—	—
oblongella*	4.99	2.70	1.80
smithii*	0.08	—	+
Epithemia			
turgida*	0.05	—	—
Eunotia	2.59	0.89	0.64
arcus	2.30	0.27	0.42
curvata	0.29	0.26	0.06
pectinalis	—	—	—
minor	—	0.29	—
valida	0.02	0.07	0.16
Fragilaria	22.43	6.69	5.33
brevistriata	0.13	3.69	0.59
inflata*	22.23	0.13	3.00
capucina	—	—	—
lanceolata*	0.03	0.06	0.08
construens	—	—	0.08
pumila*	0.01	0.02	0.02
subsalina*	—	0.10	0.26
venter	—	0.12	0.24
lepostauron*	+	0.09	0.19
dubia*	—	2.03	0.14
pinnata*	0.01	+	0.02
intercedens*	—	0.08	0.01
lancettula*	—	0.05	+
vaucheriae	0.01	0.28	0.45
capitallata*	—	0.03	0.12
sp	—	+	0.12
sp	—	0.01	+
Frustulia	—	0.07	+
rhomboides	—	0.02	—
vulgaris	—	0.05	+
Gomphonema	15.87	13.40	12.28
acuminatum	—	—	0.02
brebissonii*	0.05	+	0.15
coronata	+	—	0.21
trigonocephala*	0.15	—	—
angustatum	0.36	0.52	0.30
naviculiformis*	0.10	—	+
sacrophagus	0.06	+	+
constrictum	—	+	0.15
gracile	0.08	0.01	0.11
aurita	1.85	0.31	0.79
intricatum	0.06	0.05	0.08
dichotomum*	2.90	0.33	0.92
pumila	1.17	1.00	0.31
pusilla*	0.62	0.10	1.36
lanceolata*	0.05	—	0.01
montanum	—	0.50	0.07
subclavatum*	—	—	0.03
olivaceum	0.03	0.04	0.08
parvulum	8.32	10.50	7.69
subtile*	0.08	—	—
sp	—	0.02	—
Gyrosigma	—	1.35	0.11
accuminatum	—	0.05	0.01
attenuatum	—	1.18	0.04
spencerii	—	0.02	0.03
curvula	—	0.10	0.04
Mastogloia			
smithii			
lacustris*	0.11	—	0.02
Meridion	4.22	1.50	2.02
circulare	0.11	0.39	0.27
constrictum	4.11	1.12	1.73
Navicula	3.72	2.53	1.21
atomus	—	+	0.02
cryptocephala	0.29	0.21	0.14
veneta	0.45	0.27	0.10
elginensis	—	0.03	—
rostrata*	0.02	0.02	+
falaisensis	—	—	—
lanceolata*	0.04	—	—
halophylla	—	—	—
tenuirostris	—	0.06	—
hasta*	0.35	+	0.02
heufleri	0.11	0.80	0.02
laevissima	0.03	—	+
lanceolata	0.01	—	0.01
minima	0.03	0.03	0.08
muralis	—	+	0.01
notha*	0.20	0.18	0.02
oblonga*	0.02	0.04	0.03
paludosa	—	—	—
rhomboidea*	+	—	0.01
paucivisitata*	—	+	0.04
potzgeri*	0.09	0.01	+
pupula	0.07	0.04	0.03
radiosa	1.49	0.33	0.48
rhynochocephala	—	0.16	0.04
salinarum	—	—	—
intermidia*	0.23	—	+
seminulum	+	0.03	+
stromii	0.07	+	0.05
symmetrica	0.06	0.14	0.01
tenuloides*	0.10	0.11	0.03
tripunctata	0.03	+	0.02
schizonemoides	+	0.02	—
vanheurckii*	0.02	—	—
viridula*	—	—	0.03
rostellata	—	—	0.02
sp	—	0.01	+
sp	0.01	+	—
Neidium	0.07	0.08	0.01
binode*	0.03	0.05	+
bisulcatum*	0.04	0.02	+
Nitzschia	1.51	1.81	0.54
acicularis	+	+	+
amphibia	0.10	+	—

TABLE 1. *Continued.*

Genus species variety or form	% Relative Abundance at Stations 1	2	3
angustata	0.08	0.04	+
acuta	0.07	—	—
apiculata	—	0.05	+
capitellata	+	0.02	—
denticula	0.03	—	0.05
dissipata	0.02	0.09	0.01
filiformis	—	0.04	—
fonticola	0.01	0.04	0.01
frustulum	0.18	0.04	0.06
gracilis	0.03	0.16	0.14
linearis	0.16	0.43	0.04
palea	0.24	0.43	0.07
recta*	0.06	0.08	0.02
romana	0.02	—	—
stagnorum	—	0.02	—
sublinearis	0.08	0.11	0.07
tropica*	—	0.04	—
vivax*	0.25	+	0.01
sp	0.16	0.16	0.05
sp	0.02	0.02	—
sp	—	0.02	—
Opephora	—	0.69	0.04
ansata*	—	0.08	0.02
martyi*	—	0.61	0.02
Pinnularia	0.11	0.09	0.03
abaujensis	—	—	—
rostrata*	0.02	—	—
appendiculata*	0.02	0.01	—
brevicostata*	—	0.02	—

Genus species variety or form	% Relative Abundance at Stations 1	2	3
vividis*	0.02	0.03	0.03
minor*	0.01	0.03	—
sp	0.04	+	—
Rhoicosphenia			
curvata	—	0.12	0.02
Rhopalodia			
gibba*	0.07	—	0.01
Stauroneis	0.24	0.69	0.08
anceps	0.02	0.04	0.01
phoenicenteron	—	—	—
brunii*	+	0.03	0.01
gracilis*	0.02	0.01	—
smithii	0.19	0.59	0.06
sp	—	0.02	—
Surirella			
angusta	0.06	0.18	0.02
Synedra	3.81	4.81	0.60
affinis*	0.21	—	—
amphicephala*	0.03	0.11	—
fasciculata	0.87	2.99	0.09
truncata*	—	0.11	—
filiformis	—	—	—
exilis	2.21	0.52	0.14
minuscula*	0.03	0.33	0.05
parasitica	0.06	0.35	0.07
subconstricta	0.05	0.02	+
radians*	0.34	0.21	0.02
ulna	—	0.02	—
longissima*	0.01	0.05	0.18
subaequalis*	—	0.12	0.04

RESULTS

Identification of 53,716 valves showed 190 taxa of diatoms, with 82 representing new records for Ohio (Hufford, 1973). These data exclude forms represented by only one specimen or one valve. The Pennales were represented by 187 taxa and the Centrales by a single genus with three species (table 1).

The dominant taxa (those representing 10% or more of the total number counted) in Cedar Run were *Achnanthes minutissima* Kutz. (25.6%) and *Cocconeis placentula* Ehr. (10.2%). Four other diatoms, *Gomphonema parvulum* Kutz (8.8%), *Fragilaria brevistriata* var. *inflata* (Pant.) Hust. (8.4%), *Cocconeis placentula* var. *lineata* (Ehr.) VH. (7.8%), and *Cocconeis placentula* var. *euglypta* (Ehr.) Cl. (5.2%) were present in a relative abundance above 5% but less than 10%. These six taxa represented almost two-thirds of the total (table 1).

The dominants at station 1 were *F. brevistriata* var. *inflata* (22.2%) and *A. minutissima* (20.1%); at station 2 were *A. minutissima* (24.8%), *C. placentula* var. *euglypta* (13.1%), and *G. parvulum* (10.5%); at station 3, were *A. minutissima* (31.8%), *C. placentula* (20.1%), and *C. placentula* var. *lineata* (19.7%).

Ordination analysis of the data for each of the three stations on 16 different collection dates are indicated in figure 1. Collections from a station, in each case, were more similar to other collections from that same station than to those of other stations. Seasonal influence could not be determined from the pooled data (fig. 2) but when the data were plotted by station (fig. 1), a seasonal effect was evident. Winter data

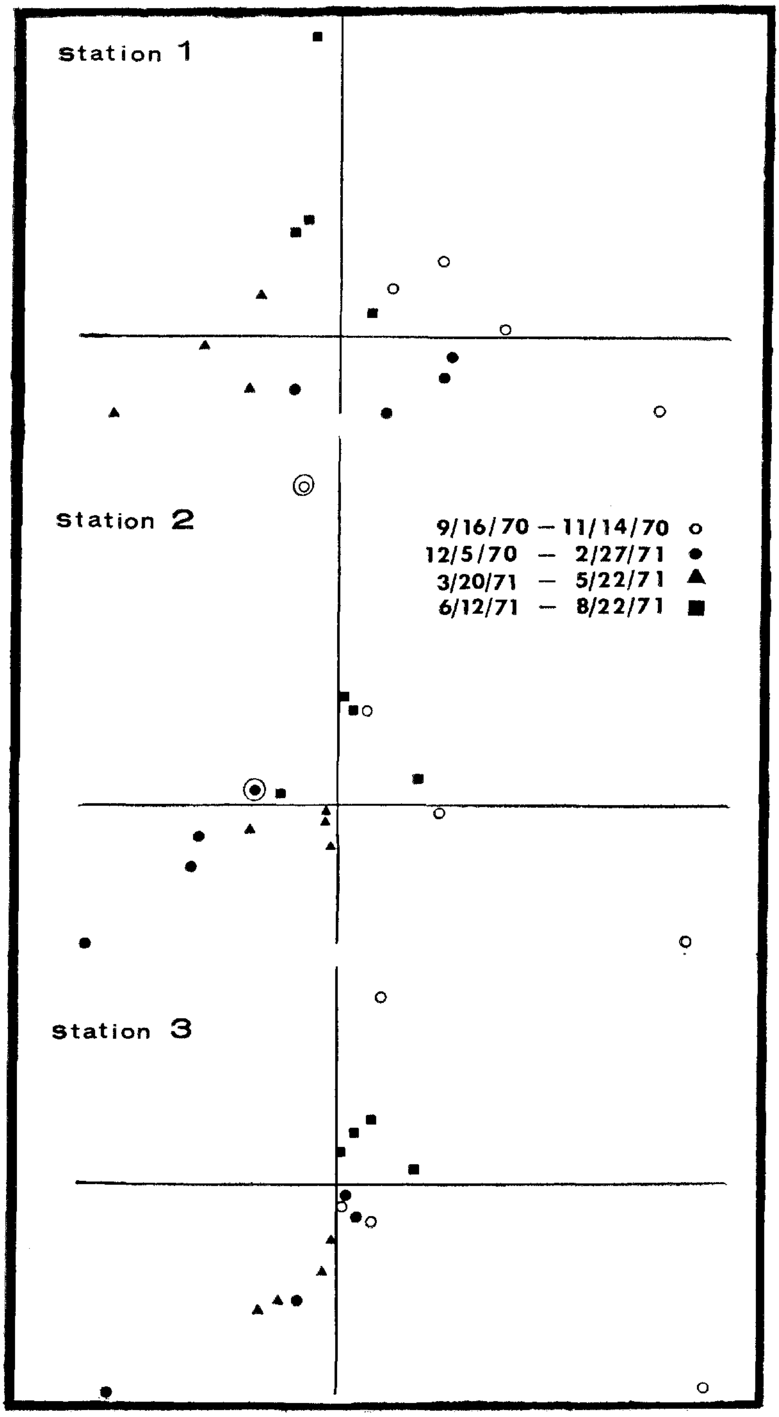

FIGURE 1. An X–Y plot based on ordination of logarithmically transformed data for Stations 1, 2, and 3 from 16 September 1970 through 22 August 1971.

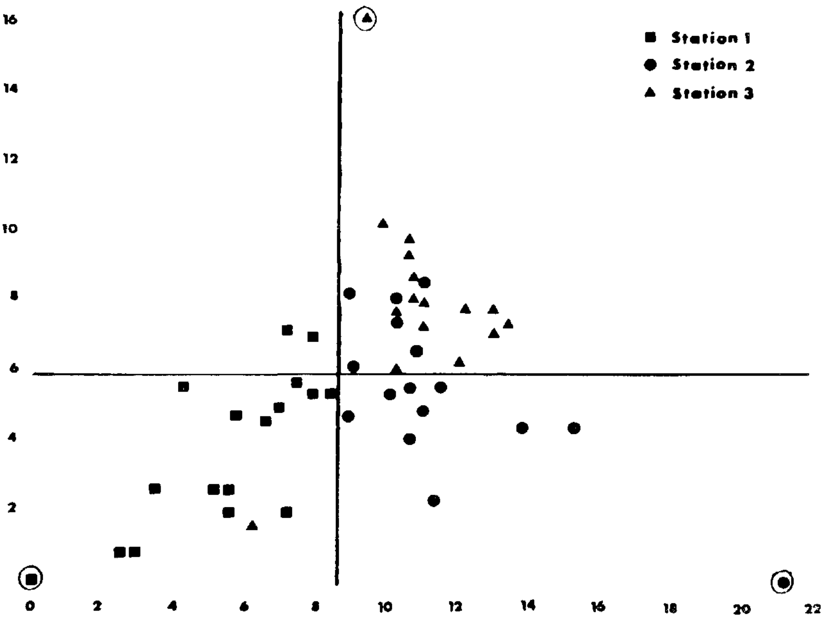

FIGURE 2. An X–Y plot based on the ordination of logarithmically transformed data for all stations and collection dates. Three sets of data (set off in circles) were significantly different from the others. The circled data are from Station 2, 24 October 1970; Station 1, 14 November 1970; and Station 3, 16 January 1971.

(5 December 1970 through 27 February 1971) for station 1 were clearly separated from summer data (12 June through 22 August 1971) along a transverse axis, while spring data (20 March through 22 May 1971) clearly separated from fall data (16 September through 14 November 1970) along a vertical axis. The seasonal effect at station 2 was somewhat less pronounced. Summer-winter data again separated along a transverse axis, with one exception. The same kind of separation was shown for data from station 3, but, in general, the points indicated less clustering than those for stations 1 and 2 (fig. 1).

The general structure of the diatom community in Cedar Run is indicated in table 1. The Araphidae and Monoraphideae comprised almost 70% of the taxa. Centric forms were rare, both in relative frequency and absolute number of representatives.

The seasonal distribution patterns of the eight most abundant diatoms in Cedar Run are shown in figures 3 through 6. In general, both the relative abundance and seasonal growth peak differed for each diatom at each station. In almost every instance the sharpest growth peaks were shown for diatoms found at station 1 and the broadest for those at station 3. Note that at station 2, *F. brevistriata* var. *inflata* (fig. 4) was almost absent, and *Diploneis oblongella* (Naeg. *ex* Kutz.) Ross (fig. 6), while present in all collections, did not reach the abundance found at the other two stations. On the other hand, *C. placentula* var. *euglypta* (fig. 5) and *Cyclotella striata* (Kutz) Grun. (fig. 6) were found almost exclusively at station 2.

Achnanthes minutissima (fig. 3) was found from all collections at all times of the year but reached its greatest abundance at station 3. It could be generally characterized as exhibiting a spring maximum. *Cocconeis placentula* (fig. 3) and *C. placentula* var. *lineata* (fig. 5) exhibited summer maxima while *C. placentula* var. *euglypta* (fig. 5) exhibited a late summer-early fall maximum. *Gomphonema parvulum* (fig. 4) would best be characterized as a winter dominant, al-

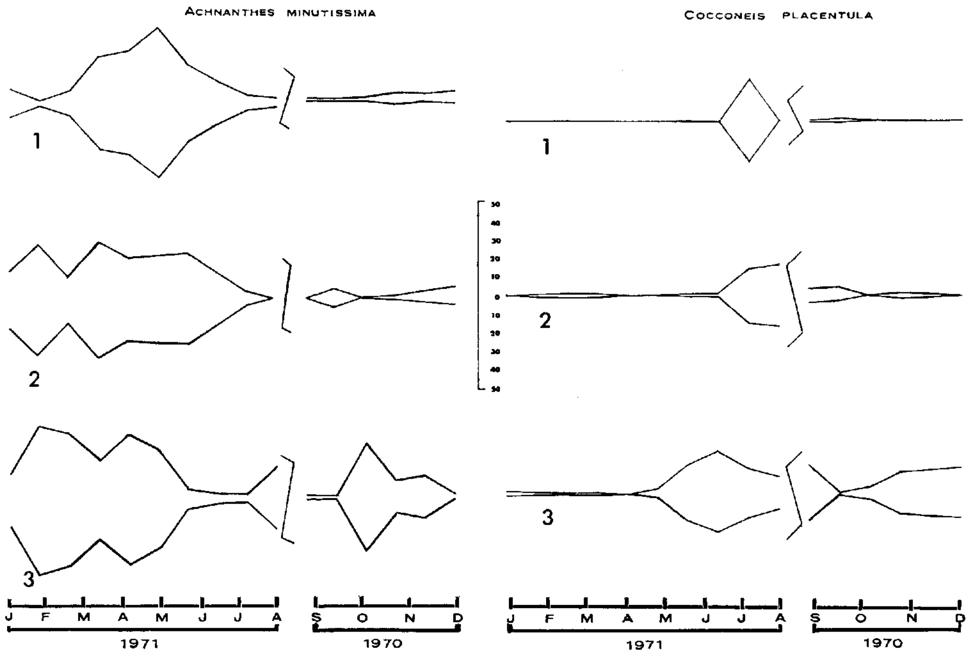

FIGURE 3. Percentage relative abundance at Stations 1, 2, and 3 of *Achnanthes minutissima* (left) and *Cocconeis placentula* (right) from 16 September 1970 through 22 August 1971.

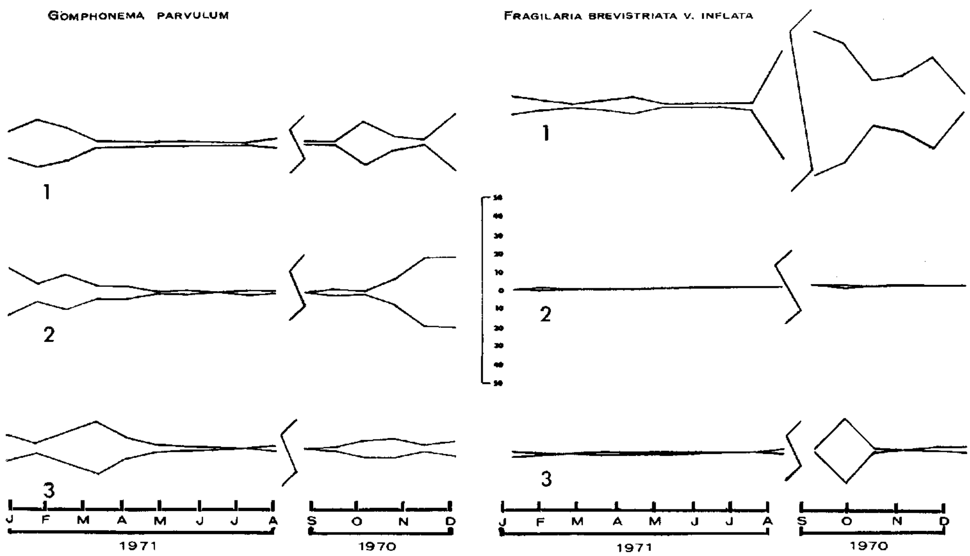

FIGURE 4. Percentage relative seasonal abundance at Stations 1, 2, and 3 of *Gomphonema parvulum* (left) and *Fragilaria brevistriata* var. *inflata* (right) from 16 September 1970 through 22 August 1971.

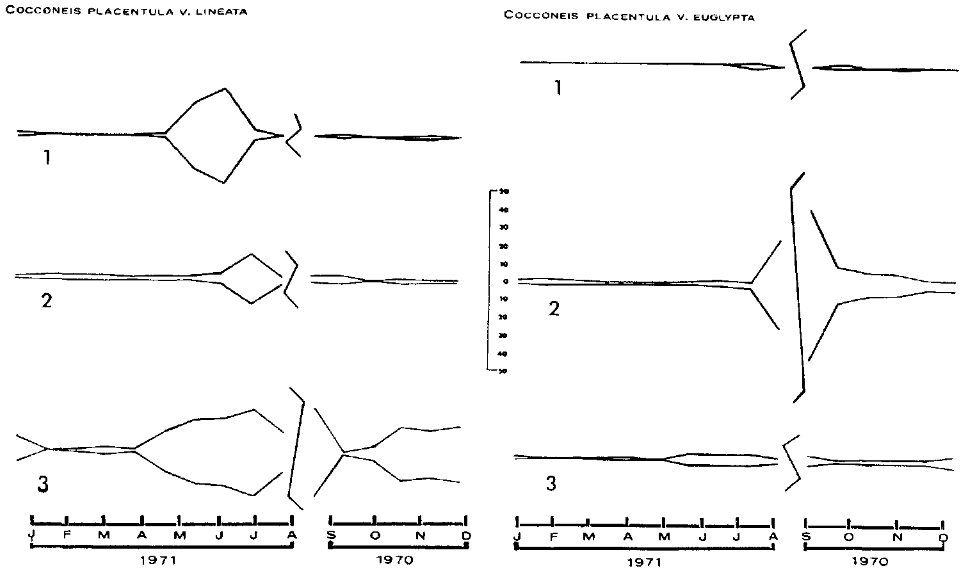

FIGURE 5. Percentage relative seasonal abundance at Stations 1, 2, and 3 of *Cocconeis placentula* var. *lineata* (left) and *Cocconeis placentula* var. *euglypta* (right) from 16 September 1970 through 22 August 1971.

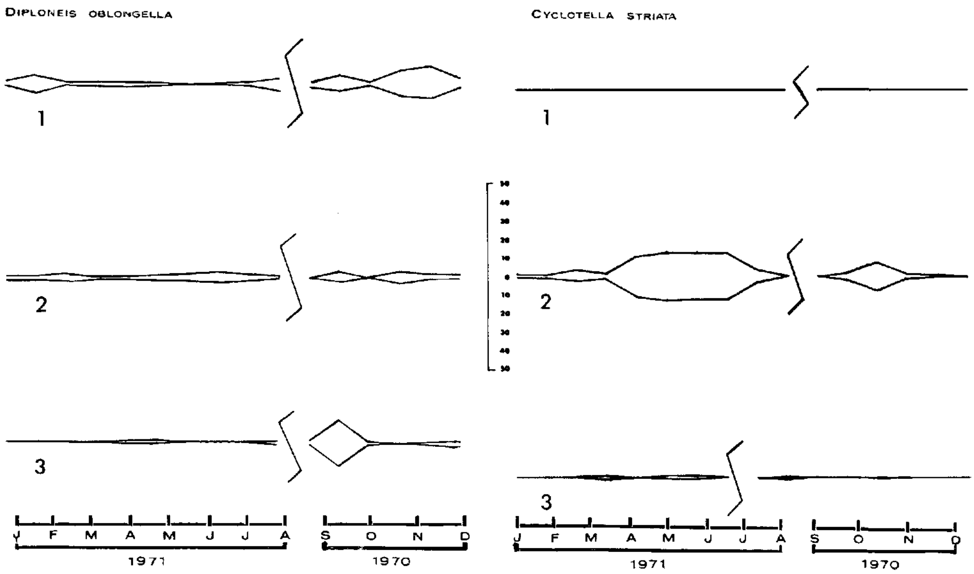

FIGURE 6. Percentage relative seasonal abundance at Stations 1, 2, and 3 of *Diploneis oblongella* (left) and *Cyclotella striata* (right) from 16 September 1970 through 22 August 1971.

though it was prevalent at all three stations from late fall through spring. *Fragilaria brevistriata* var. *inflata* (fig. 4) exhibited a fall maximum, with *Diploneis oblongella* (fig. 6) also exhibited a fall maximum at station 3, but a winter maximum at station 1. *Cyclotella striata* (fig. 6) exhibited a summer maximum at station 2, the only station at which it reached any abundance.

DISCUSSION

Published information on the diatom flora of Ohio, exclusive of Lake Erie and the Ohio River, is scarce. Collins and Kalinsky (1976) after an extensive literture search, found only 13 studies which included Ohio diatoms. These studies reported a total of 235 Ohio diatom taxa, but the actual total was somewhat less because of synomony. In their report on the Scioto River Basin, Collins and Kalinsky list 166 taxa including 99 not previously reported from Ohio. Lowe and Collins (1973) reported 41 taxa comprising an aerophilous diatom community from Hocking County, 10 of which were not previously reported for Ohio. Lowe and McCullough (1974) reported 111 diatom taxa from the North Branch of the Portage River, 25 of which were previously unreported from Ohio and Lowe and Busch (1975) reported a single taxon new for Ohio. These studies have provided 370 diatom taxa from the non-border areas of Ohio, with the present report contributing 82 additional taxa.

Multivariate analysis of algal data are not uncommon, as evidenced by the studies of Allen (1971), Allen and Koonce (1973), Levandowsky (1972a, b), but multivariate analysis of diatom communities is uncommon. Several of the investigators mentioned above have utilized modified Orloci programs (*e.g.* Allen and collaborators, and Levandowsky). There has been some criticism of Orloci's major component analysis (Gauch and Whittaker, 1972; Beals, 1973), but our results indicate its usefulness in forming various groupings or strata. Relatively clear-cut separation of stations was determined by the technique (fig. 1). The sampling stations were selected on the basis of their physical differences, and we expected the diatom communities from each station to be different. Obviously, with only 3 stations and 48 total collections to consider, we knew that the diatom communities at the 3 stations were different as the collections were being identified and counted. In addition, it was not difficult to manually analyze the data and arrive at conclusions similar to those suggested by computer analysis of the data. Computer analysis, while not absolutely necessary, did provide insight not readily available by manual scrutiny of the data. The sensitivity and validity of the program provides a valuable tool for an extensive and intensive sampling program.

Of the 190 taxa found in Cedar Run, 17 were determined to be significantly different on the basis of ordination analysis. It is these 17 taxa that contributed most to the difference between stations in the seasonal and distributional patterns. These taxa were 1) a major component at one or more stations, 2) if not a major component, at least a relatively important component at 2 of the 3 stations, but essentially absent from the third, or 3) exhibited a seasonal pattern for one station different from that for the other 2 stations. This information provided evidence for strength of the Orloci analysis; not only did it recognize differences in frequency, but it also showed differences in distributional pattern of taxa. An inherent weakness of the program is that rarely occuring taxa are not recognized as being significant. The rare occurrence or absence of a taxon, from an ecological standpoint can be just as important as its presence as a major component.

The collection from station 1, 14 November 1970, was found to consist of 69 different diatoms (total count 804 valves). Only two collections were found to have a greater number of taxa. On 26 December 1970, 70 different diatoms were identified in 946 valves, and on 24 October 1970, 71 different diatoms were identified in 1329 valves. However, the 14 November collection had the greatest number of taxa per valves counted. These data indicate that the program will compensate for differences in total count among various samples, and that sample count, per se, did not influence the groupings. Thus, while it is advisable for statistical purposes to keep the sample counts similar, it is not necessary that exactly 1000 valves be counted per sample.

The data for station 2, 24 November 1970, were found to consist of only 27 different taxa, the next to lowest number of taxa per total valves counted from that station. *Achnanthes minutissima*, species of *Nitzschia*, and species of *Synedra* were totally absent for that date. In addition, the collection contained 40 of the 51 valves of *Amphora ovalis* var. *affinis*, 60 of the 83 valves of *Cocconeis dimunita*, 325 of the 352 valves of *Fragilaria leptostauron* var. *dubia*, 200 of the 205 valves of *Gyrosigma attenuatum*, and 95 of the 105 valves of *Opephora martyi* found for station 2. The collection was unique in its total lack of *A. minutissima*, the major component of Cedar Run, and in the presence of nearly the entire populations of 5 different diatom taxa found for that station. These data confirm the sensitivity of the Orloci analysis in recognizing heterogenous distributional patterns of diatom populations.

The data for station 3, 16 January 1971, were found to produce the highest diversity index (Shannon and Weaver 1963) for any collection from that station. An additional influence on the analysis was the occurrence of all 48 valves of *Fragilaria construens* var. *subsalina*, 12 of 15 valves of *Gomphonema olivaceum*, and 292 of 321 valves of *Meridion circulare* var. *constrictum* recovered from station 2.

Although seasonal influence is not apparent from the data as presented in figure 2, ordination of the data from each station, independent of that from other stations, did indicate a seasonal effect (fig. 1). Although fall, winter, spring, and summer collections do not separate into different quadrants, they do separate along an axis. Only at station 2 was there incomplete separation of winter collections from summer (along a transverse axis), and fall collections from spring (along a vertical axis). The aberrant points are circled (fig. 1). This seasonal separation can be attributed, in part, to differences in diversity. In general, the highest diversity indexes were found for fall and winter collections, the lowest for spring and summer collections, but diversity differences alone cannot account for the distribution. Species distribution and frequency of occurrence are additional factors to be considered.

Our data of *Cocconeis* spp. concur with those found by Butcher (1932) for English rivers, however, Schroeder (1939) and Hornung (1959) determined the taxa to exhibit fall maxima. Our data did confirm early fall maxima at station 3 for *C. placentula* and *C. placentula* var. *lineata*, and an early fall maximum at station 2 for *C. placentula* var. *euglypta*, but after September, the populations, in general, fell off rapidly with the exception of station 3. We did note an unusual winter secondary growth peak for *C. placentula* and *C. placentula* var. *lineata* from station 3. We have no explanation for this phenomenon. Apparently the growth of *Cocconeis* spp. is not correlated strongly to seasonal aspects.

Cholnoky (1968) pointed out that the development of diatom associations is determined not by the topographic site, but by the chemo-physical conditions of their habitat. This accounts, in part, for the cosmopolitan nature of many diatoms. Our results, in general, support Cholnoky's views, as the principal diatoms of Cedar Run are also major components of the diatom flora of other streams having calcium levels similar to those of Cedar Run (approximately 100 mg/ℓ). Chemical differences alone do not explain diatom periodicity. Obviously temperature, current and light are important factors in the distribution of certain diatoms, while for others it has minor significance. It is known that centric diatoms are common to lakes, ponds, and large rivers, but uncommon in small, rapidly flowering streams, and over 96% of all centric diatoms identified from Cedar Run occurred at station 2, an area of West Branch choked with fallen trees, branches, *Chara*, and *Nasturtium*, where current was almost negligible and a pooled condition existed.

When the known environmental requirements of the 8 most abundant diatoms in Cedar Run were considered, certain water quality parameters for

Cedar Run became apparent. *Achnanthes minutissima* was characterized by Hustedt (1938) as one of the more ubiquitous diatoms. It has a reported pH range from 4.3 to 9.2 (Hustedt, 1938; Foged, 1948; Bock, 1952; Scheele, 1952). Cholnoky (1968) reported a pH optimum of 7.5 to 7.8. Thus, it is not surprising that this diatom was the most common taxon in Cedar Run.

Cholnoky (1960) stated that *C. placentula* has a narrow optimum around pH 8, with its varieties having ecological requirements indistinguishable from those of the type. Our results do not support either of his contentions. *Cocconeis placentula* and *C. placentula* var. *lineata* reached their greatest development at station 3, where pH was generally less than 7.8, lower than at any other station for comparable dates. Other references give a pH range of 4.7–9.0 for *C. placentula* and *C. placentula* var. *lineata*, and 6.2–9.0 for *C. placentula* var. *euglypta* (Foged, 1948; Jorgensen, 1948). Factors other than pH have been suggested as influencing the growth of *C. placentula*. Hustedt (1938) pointed out the importance of substratum for the growth of *C. placentula* and its varieties. Lowe (1972) also noted the importance of substratum to explain the high numbers of *C. placentula* var. *euglypta* found at one station in an Iowa drainage ditch. Both authors have associated the maximum growth of *C. placentula* with the concommitent presence of filamentous algae such as *Rhizoclonium*, *Stigeoclonium*, or *Cladophora*. Butcher (1932), however, cited extensive growth of *C. placentula* on the river bed and did not associate its numbers with "host" plants such as those mentioned above. Cholnoky (1968) stated that there was absolutely no association between diatom and substratum, and that a diatom could exist equally well on aquatic plants or a variety of inanimate substrata. The observations of Hustedt and Lowe as opposed to those of Butcher would tend to support Cholnoky's view, while our data do not support or deny this assumption. Previous investigation (Hufford and Collins, 1972) and personal observation of the underwater portions of *Chara* and *Nasturtium* indicated that living and non-living substrata did not support the same communities of diatoms. Although the kinds of diatoms from each habitat were essentially the same, the populations of each were not.

It has been shown that certain diatom taxa do not colonize glass slides to the same degree that they exist in their natural habitat. This may not be due simply to a difference in living versus non-living substrates. Butcher (1932) found that *Cocconeis* did not populate glass slides to the degree they populated the stream bed, yet both substrates were inanimate. He explained this anomaly by observing that *Cocconeis* is adnate and tends to adhere rather tightly to the substratum. Diatoms of this type will become free-floating, but not in proportion to their abundance on the stream bed. Thus, less will be collected off the glass slides of the diatometer. This may ex-explain the reduced numbers of *C. placentula* at station 1, a station lacking aquatic macrophytes but having chemical parameters which should support growth of *Cocconeis*. The reduced numbers of *C. placentula* could also be explained on the same basis.

Cholnoky (1968) described *G. parvulum* as having a pH optimum of 7.8 to 8.2, while the data of Hustedt (1938), Foged (1948), and Scheele (1952) presents a pH range of 4.2 to 9.0 for the taxon. It is tolerant of rather highly polluted water (Butcher 1947), but will be found in clean water as well. It can best be described as pollution-tolerant, not pollution-dependent. Cholnoky (1960) stated that while *Nitzschia* species indicated moderately strong pollution and high nitrogen levels, *G. parvulum* was indicative of changing or fluctuating nitrogen concentrations. *Nitzschia* species comprised less than 1% of all diatoms observed from Cedar Run.

Patrick and Reimer (1966) stated *F. brevistriata* var. *inflata* is characteristic of alkaline waters of fairly high conductivity. Conductivity in Cedar Run is fairly high (approximately 770–780 mhos/cm), but as the waters of the northern parts of East and West branches have essentially the same conductance, the almost complete lack of *F. brevistriata* var. *inflata* from station 2 cannot be explained on that basis. The nominate form, *F. brevistriata* has its maximum growth at station 2. Obviously, the two taxa cannot be lumped together; they have different ecological requirements but our data do not allow us to hypothesize regarding the nature of those requirements.

The abundance of *Cyclotella striata* at station 2 must be considered somewhat unusual. Cholnoky (1968) stated it was a salt water form found in littoral areas of the sea and in estuaries, and classified this diatom as mesohalobous, occuring in salt concentrations of 500 to 30,000 mg/ℓ. Foged (on various occasions) has classified it as euryhalobous (1948), occurring over broad ranges of salt concentration, to mesohalobous (1949), while Hustedt (1930) has described it as mesohalobous to euhalobous (a marine form, occurring in salt concentrations of 30,000 to 40,000 mg/ℓ). Weber (1971) reported *C. striata* from the Delaware and Hudson Rivers, while Drum (1964) reported it from the Des Moines River in Iowa. The taxon would certainly seem to be euryhalobous. The ecological significance of *C. striata* occurring exclusively at station 2 is probably related in part to high conductivity and in part to the absence of a current.

Our data indicate that ordination analyses of diatom associations yield a pertinent basis for drawing conclusions regarding environmental aspects of the habitats from which the diatoms were taken. Utilizing present data, previous experiences, and published information regarding ecological requirements of specific diatoms, we infer that 1) Cedar Run could not be considered a "polluted" stream, 2) nitrogen levels fluctuate, with relatively high concentrations present at certain times, 3) the waters of Cedar Run are alkaline and well-oxygenated, 4) conductivity is relatively high, and 5) pH could reach an optimum of 8.0 to 8.2 but would rarely fall below 7.0. Cedar Run is not a homogeneous stream even within the reaches encompassed by Cedar Bog, and it does have a diverse diatom flora.

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